FINAL REPORT

Assessment of Geology, Energy, and Minerals (GEM) Resources

SUMMER LAKE GEM RESOURCE AREA

(OR-010-27)

LAKE COUNTY, OREGON

Prepared for

United States Department of the Interior
United States Bureau of Land Management
Scientific Systems Development Branch

March 1983

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Summer Lake GRA (OR - 010 - 27) Lake County, Oregon

Prepared For:

United States Department of the Interior
United States Bureau of Land Management
Scientific Systems Development Branch

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This report was prepared as part of a Phase I Assessment of GEM Resources within designated Wilderness Study Areas in Oregon, Idaho and Nevada.

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DISCLAIMER

This document is part of a report prepared under Contract Number YA - 553 - CT2 - 1042 for the United States Department of the Interior, Bureau of Land Management. Although officials of the Bureau of Land Management have provided guidance and assistance in all stages of the project, the contents and conclusions contained herein do not necessarily represent the opinions or policies of the Bureau.

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- Dr. Antonius Budding - Oil Shale and Tar Sands
- Mr. Raymond Corcoran - Field Verification
- Dr. James Firby - Paleontology
- Mr. Ralph Mason - Coal
- Mr. Richard Miller - Uranium and Thorium
- Mr. Vernon Newton - Oil and Gas
- Mr. Herbert Schlicker - Industrial Minerals and Geologic Hazards
- Dr. Walter Youngquist - Geothermal
- Dr. Paul Weis - Metals and Non - Metals.

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Ms. Pamela Ruhl provided clerical and editorial assistance throughout the project. Ms. Sara Mathews assisted with occurrence information and drafting. Mr. Philip R. Jones and Mr. Michael A. Becker produced all documents relating to the project using TERRADATA's word processing and document production systems.

EXECUTIVE SUMMARY

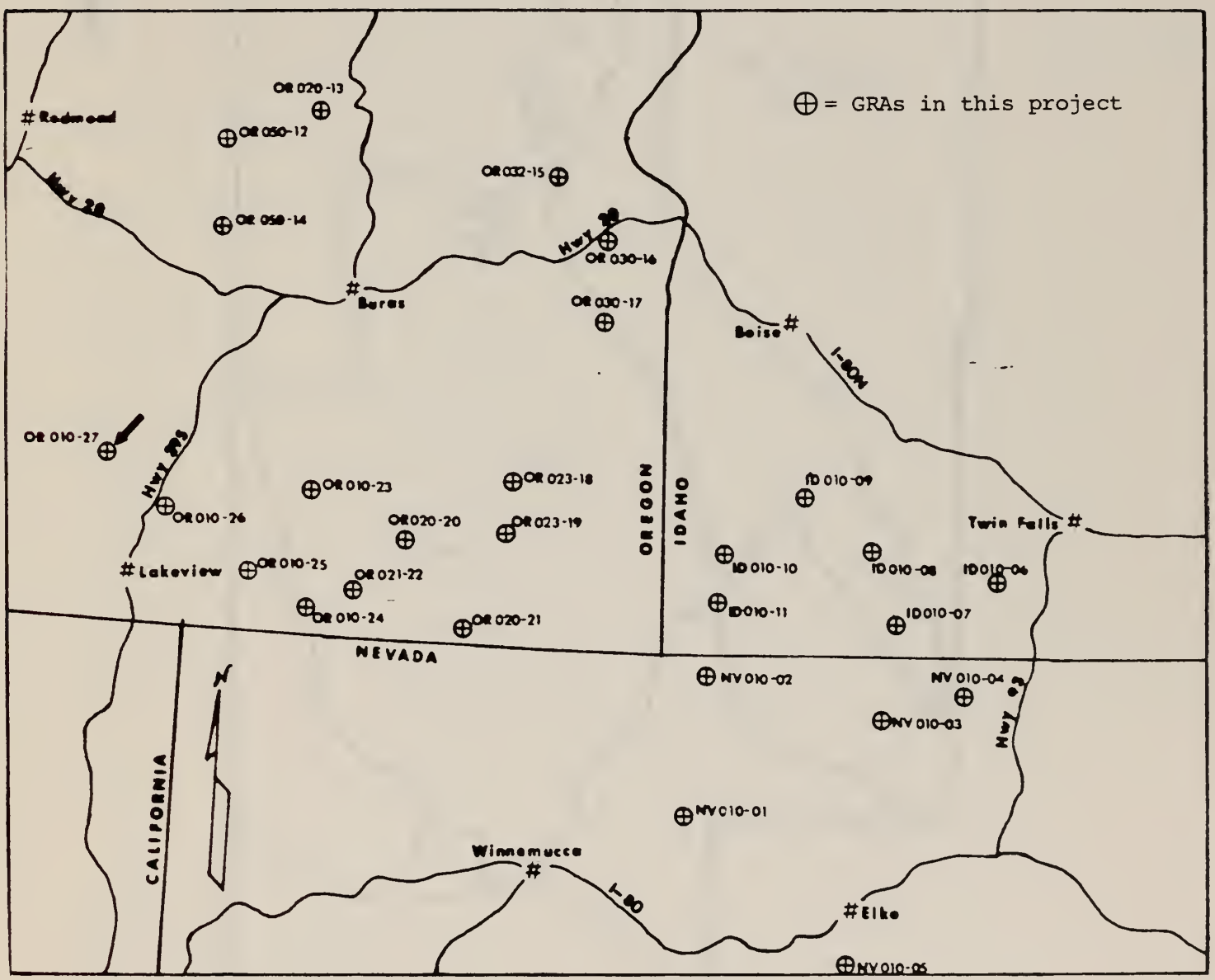
The purpose of this project is to evaluate and classify environments favorable for the occurrence of GEM resources in southeastern Oregon, southwestern Idaho, and northern Nevada. **(See the TERRADATA report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.")** GEM resource environments have been rated on a scale that ranges from one to four, with one being least favorable and four being most favorable. Favorability classes two and three represent low and moderate favorability, respectively. Confidence levels range from A to D with A being low confidence and D being high confidence. The confidence levels are directly related to the quantity and quality of the information available for the determination of the favorability classes.

The specific area with which this report deals is the Summer Lake GEM resource area (GRA OR-010-27) which is located in south-central Oregon (see location map, below). The GRA contains about 506 square miles within Townships 29S through 33S and Ranges 17E through 19E. It contains one WSA; WSA 1-58 which comprises 113,120 acres. The study area is in the High Desert Resource Area of the Lakeview BLM District. It is about 35 miles from Lakeview, Oregon.

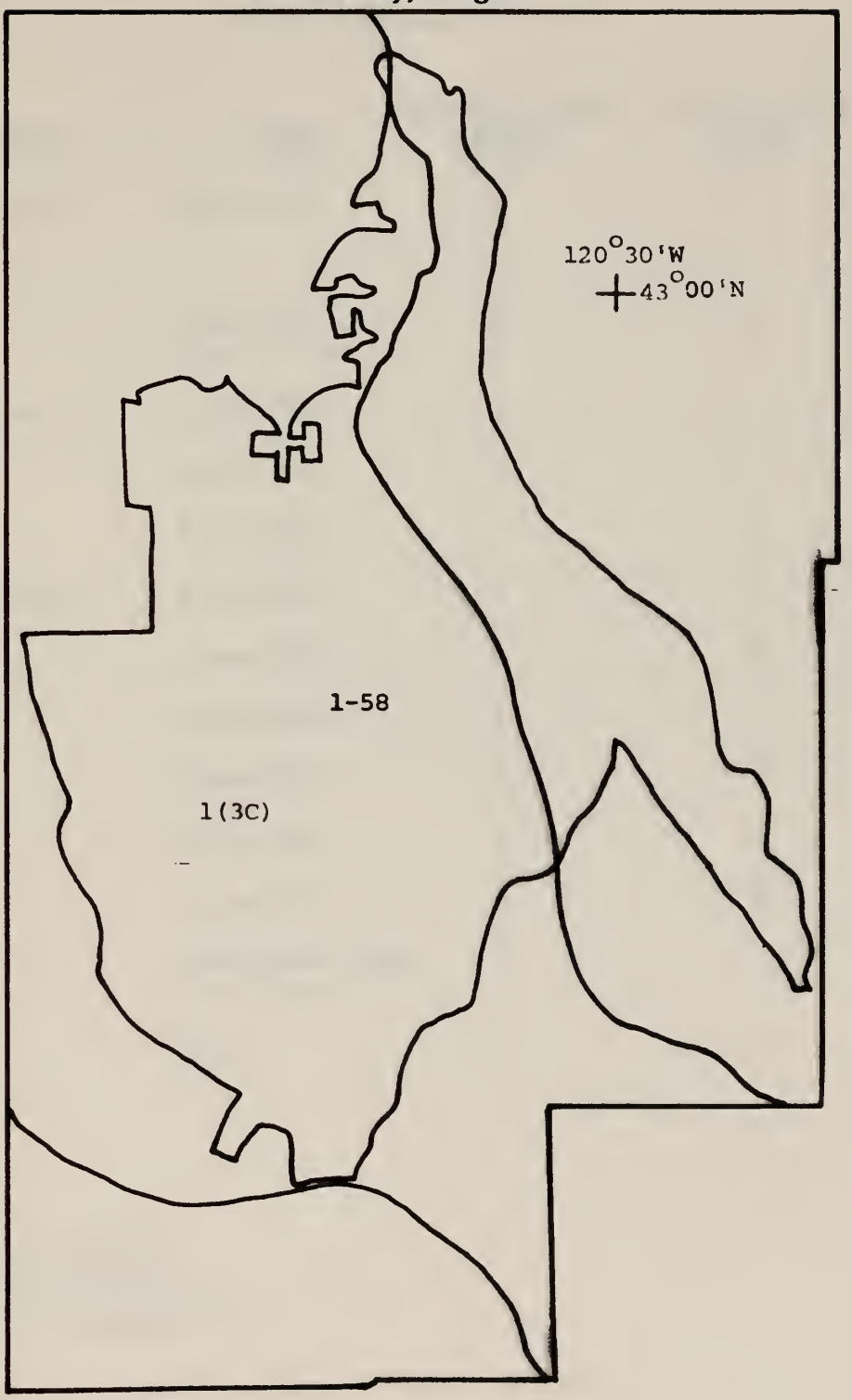
The GRA is within the Great Basin sub-province of the Basin and Range physiographic province. It is underlain by rocks that range from Paleozoic miogeoclinal sediments to Tertiary volcanic and volcaniclastic strata. The area is west of the major structural Antler orogenic belt. Basin and Range fault blocks are common in this portion of Oregon.

The Summer Lake GRA contains several geologic environments that are variously favorable for GEM resources. The area labeled 1-3C on the land classification map below is moderately favorable for the occurrence of geothermal resources. This classification signifies that the geologic environment, inferred sub-surface processes and reported occurrences indicate a moderate favorability for the occurrence of geothermal resources. The available data provide direct evidence to support the evaluation. The remainder of the Summer Lake GRA is not favorable (Class 1B) for geothermal resources. The GRA is moderately favorable (Class 3B) for the occurrence of non-metallic evaporitic salts, potassium salts, and possibly, borate resources.

GRA Location Map



Land Classification Map
Summer Lake GRA
(OR - 010 - 27)
Lake County, Oregon



Scale 1:250,000
(Klamath Falls and Crescent $1^{\circ}x2^{\circ}$ NTMS Quadrangles)

Classification Of Lands Within The
Summer Lake GRA
(OR - 010 - 27)
Lake County, Oregon
For GEM Resource Potential

COMMODITY	AREA	CLASSIFICATION LEVEL	CONFIDENCE LEVEL	REMARKS
Metals/Non-Metals	Entire GRA	3	B	Sodium Salt, Potassium Salt, and Borates
Geothermal	Area 1-3C	3	C	
	Rest of GRA	1	B	
Uranium/Thorium	Entire GRA	1	A	
Coal	Entire GRA	2	B	
Oil and Gas	Entire GRA	3	B	
Tar Sands/Oil Shale	Entire GRA	1	C	
Limestone	Entire GRA	1	B	
Bentonite	Entire GRA	2	C	
Diatomite	Entire GRA	2	C	
Clinoptilolite	Entire GRA	1	C	
Paleontology	Entire GRA	4	B	
Hazards	See Hazards Map (GRA File)			
ESLs	None	1	C	

LEGEND:
Class 1 - Least Favorable
Class 2 - Low Favorability
Class 3 - Moderate Favorability
Class 4 - High Favorability

Confidence Level A - Insufficient data or no direct evidence
Confidence Level B - Indirect evidence available
Confidence Level C - Direct evidence but quantitatively minimal
Confidence Level D - Abundant direct and indirect evidence

This classification signifies that the geologic environment, the inferred geologic processes and the reported mineral occurrences indicate moderate favorability for the accumulation of evaporative salts and borates. The available data provide indirect evidence (Level B) to support the possible existence of these mineral resources.

There is a high favorability for the presence of paleontological resources. Lacustrine and tuffaceous sedimentary rocks in the area are known to contain Pliestocene fossils.

The entire GRA is moderately favorable for the occurrence of oil and gas resources. It lies within the margin of the western Triassic marine basin and contains some gas-shows in water-wells.

The entire GRA also is favorable to varying degrees for coal, diatomite, and bentonite resources.

TERRADATA recommends that further surface geologic investigations be undertaken in the Summer Lake GRA in order to increase confidence levels in classifications. Detailed geologic mapping and geochemical investigations would be useful in upgrading the land classifications of this area. Selective drilling of geochemical and/or geophysical anomalous areas would contribute to the refinement of the confidence levels and favorability ratings in this GRA.

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1. INTRODUCTION

This report is one of 27 GRA technical reports that summarize the results of a Phase 1 assessment of the geology, energy, and minerals (GEM) resources in selected portions of southeastern Oregon, southwestern Idaho, and northern Nevada. The study region was subdivided into 27 GEM resource areas (GRAs), principally for ease of data management and interpretation. The assessment of GEM resources for this project consisted of an interpretation of existing literature and information by experts knowledgeable in both the geographic area and specific commodities. It is possible that the assessment would be different if detailed field exploration, geochemical sampling, and exploratory drilling programs were undertaken. (See the TERRADATA report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.")

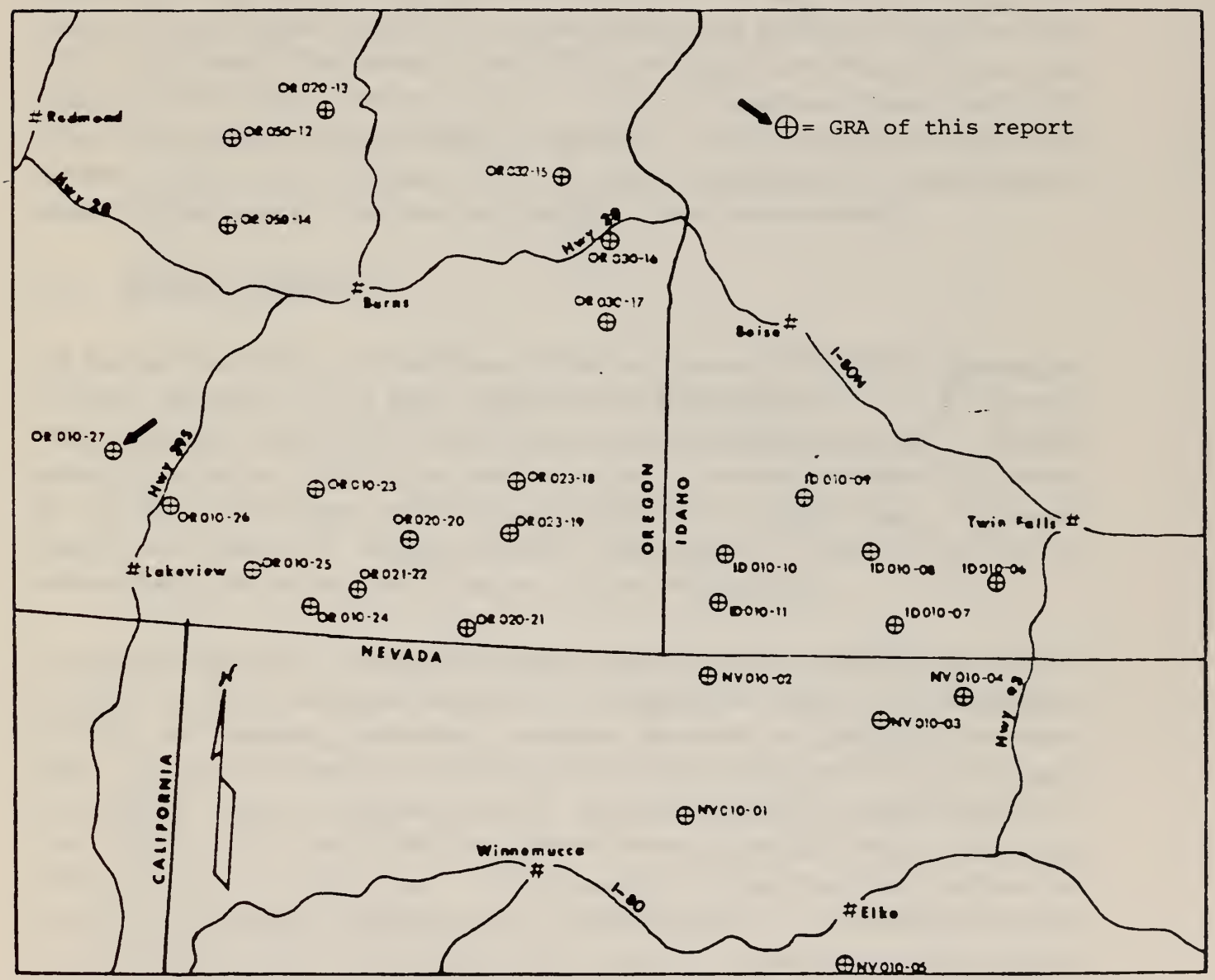
This report summarizes the assessment of the GEM resources potential of the Summer Lake GRA (OR-010-27). See Figure 1-1. Commodity categories for which this GRA was evaluated are:

- Metals
- Oil and Gas
- Oil Shale and Tar Sands
- Geothermal
- Uranium and Thorium
- Coal
- Industrial Minerals
- Paleontological Resources
- Geologic Hazards
- Educational and Scientific Localities (ESLs)

Geologic environments within the Summer Lake GRA have been rated with respect to their favorability for the occurrence of these different commodities. The favorability rating scale ranges from one to four, with one being least favorable and four being most favorable. Confidence levels in these ratings also have been assigned. These confidence levels range from A to D, with A being low confidence and D high confidence. Assigned confidence levels are related to the quantity and quality of the information available for the determination of the favorability ratings.

FIGURE 1-1

GRA Location Map



2. DESCRIPTION OF THE SUMMER LAKE GRA

2.1 LOCATION

The Summer Lake GRA (OR-010-27) is in south-central Oregon. It lies between latitudes 42°40'N and 43°10'N and longitudes 120°22'W and 120°46'W. The GRA contains approximately 504 square miles within Townships 29S through 33S and Ranges 17E through 19E (see Figures 1-1 and 2-1). The area contains one Wilderness Study Area; WSA 1-58 (113,120 acres). The Summer Lake GRA is in the High Desert Resource Area of the Lakeview BLM District. The area is about 35 miles from Lakeview, Oregon which is the nearest transportation center offering a minimum of rail, highway, and/or charter-air services. Access to the contained WSA is via county maintained dirt or packed-gravel roads. Vehicular access to the interior of the WSA is poor to non-existent.

2.2 GENERAL GEOLOGY

The Summer Lake GRA is in the Klamath Falls and Crescent 1°x2° NTMS Quadrangles. The data available for this area includes NURE investigations[1, 2, 3, 4]*; general mineral resource information[5], and limited small-scale geologic mapping[6]. Detailed geologic information is lacking for most of the area. Occurrence evaluated information for this GRA includes data from MILS, CRIB, NURE, claims, and leases. The overall quantity and quality of commodity-specific information is poor to fair for all commodities; most are not known to occur in or near the study area.

The Summer Lake GRA is within the northern section of the Great Basin sub-province of the Basin and Range physiographic province. The Basin and Range Province consists of generally north-trending fault-block mountains separated by parallel intermontane basins. The mountain blocks are commonly ten to twelve miles wide and are separated by alluviated valleys of comparable width. Elevation ranges from below sea-level at Death Valley to more than 13,000 feet at White Mountains Boundary Peaks. Local relief generally is less that 5,000 feet. The physiography of the Great Basin reflects the structural and lithologic complexity of the underlying bedrock. The Great Basin portion of the Basin and Range Province extends from southern Nevada northward into southern Oregon. The northern-most extremity is located just north of the town of Burns, Oregon. Rocks in the area range from Paleozoic eugeoclinal-miogeoclinal suites to Tertiary volcanogenic and lacustrine strata.

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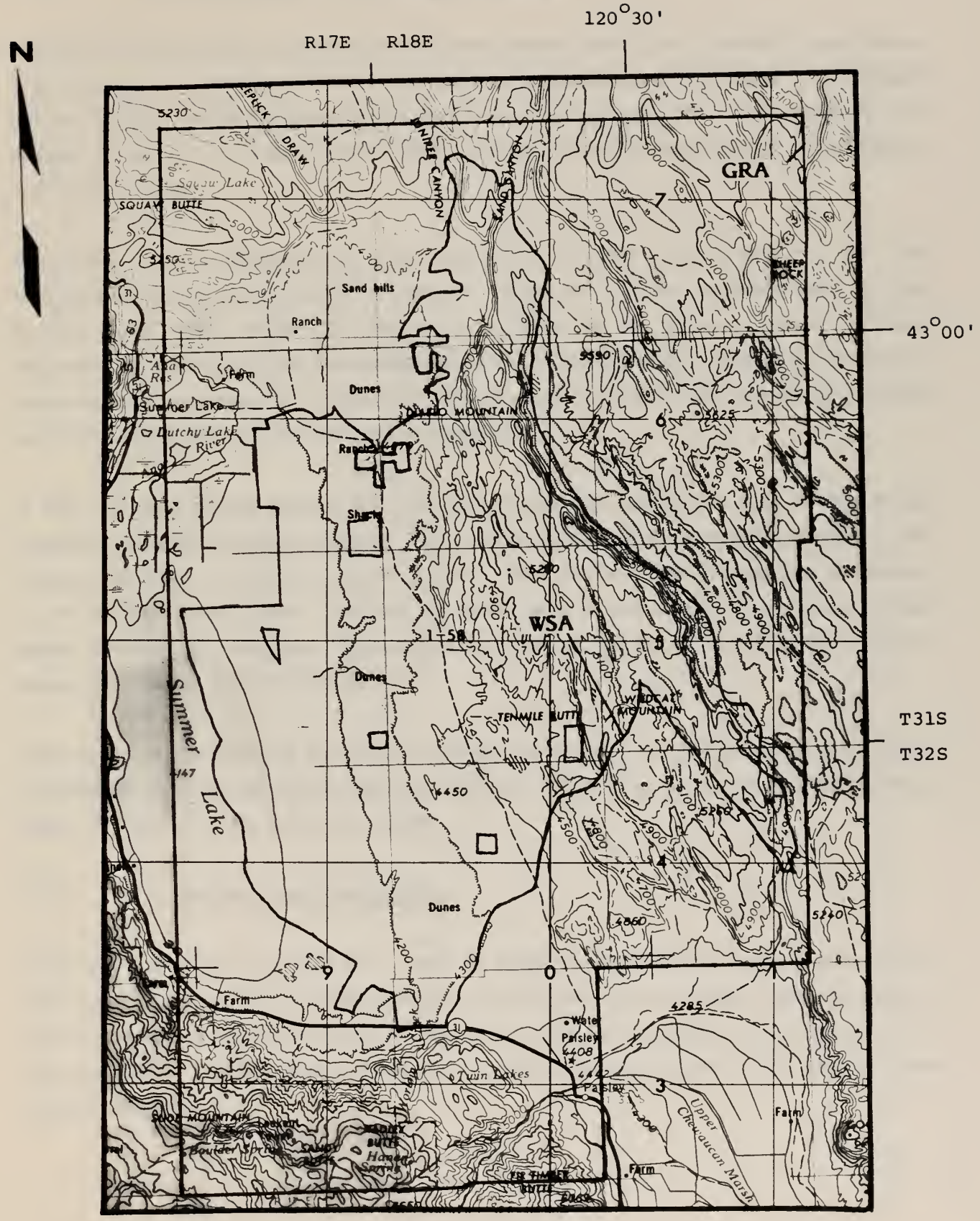
* In this report, citations are superscripted numbers. They refer to bibliographic entries listed in Appendix A, References Cited.

FIGURE 2-1

Topographic Map
Summer Lake GRA
(OR-010-27)
Lake County, Oregon



Scale 1:250,000
(Klamath Falls and Crescent 1°x2° NTMS Quadrangles)

TERRADATA
San Francisco
Denver

2.2.1 Geomorphology

The Summer Lake GRA is located in the west-central end of the Summer Lake graben. The Summer Lake graben is one of several prominent sub-parallel grabens in the Oregon portion of the Basin and Range Province. Other major grabens that occur in this part of Oregon include Crump Lake Valley, Catlow Valley, Warner Lakes Valley, Guano Valley, and Pueblo Valley.

The study area is contained entirely within the Summer Lake graben. North and northwest-trending escarpments, especially prominent in the southern part of the Summer Lake GRA, define the approximate limits of the graben. Upland surfaces represent 50 percent of the area within the GRA. The southern one-half of the area is characterized by playa-type landforms. The area is essentially flat, contains dunes and sand hills, playa lake strand-lines and marshlands.

A high drainage divide crosses the northeast corner of the GRA. East of this divide ephemeral streams drain southward. The area is capped by olivine-bearing basalt on the downthrown block of another smaller graben. West of the divide the drainage is internal to the Summer Lake basin. Streams on either side of the divide are sub-parallel and appear to be fault-controlled. The southwest portion of the GRA, near Slide Mountain, is drained by Worlow and Annie Creeks.

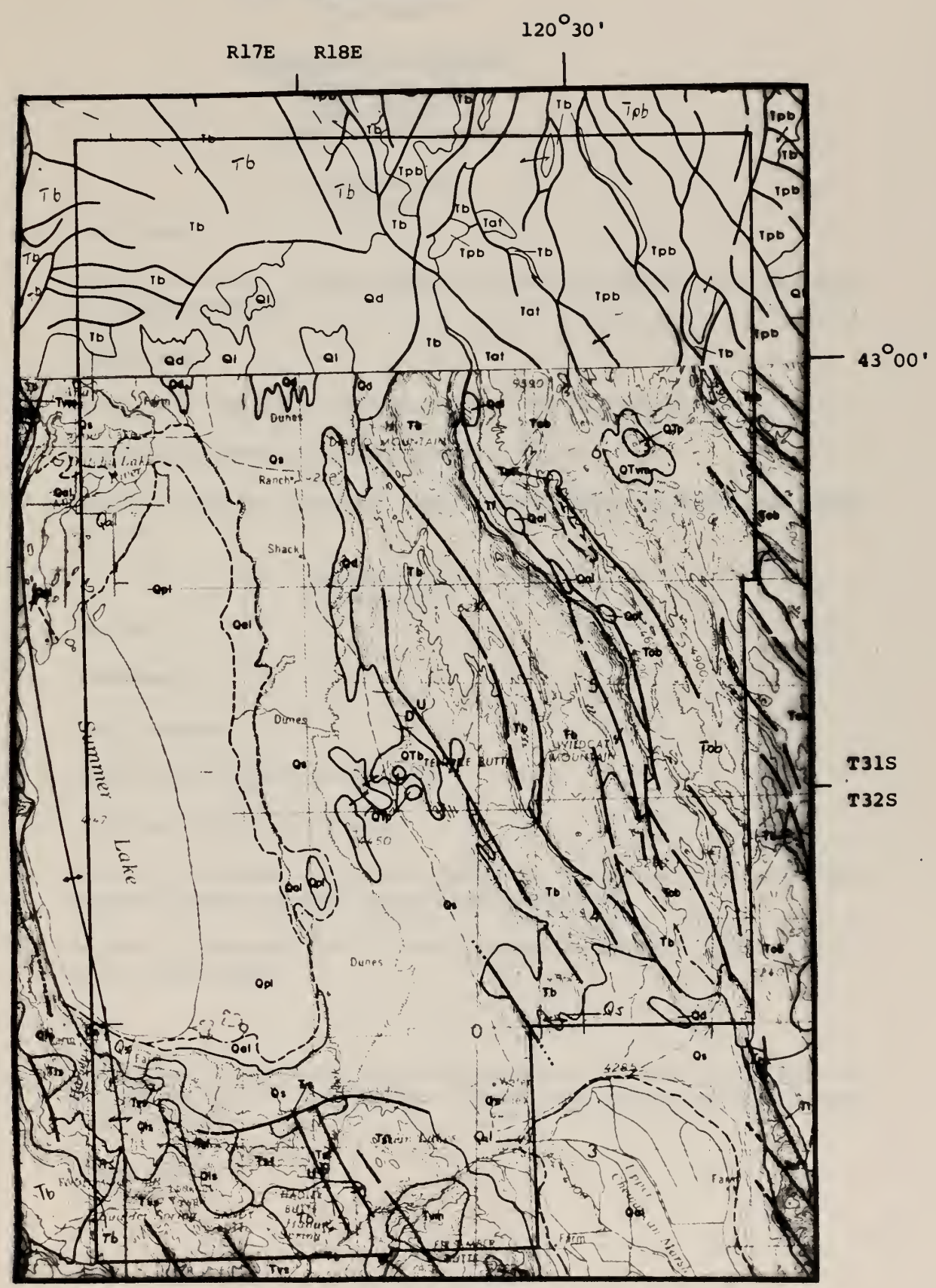
Total relief in the Summer Lake GRA is about 1,800 feet. The highest point is in excess of 6,000 feet. It occurs in the east-central part of the area along the prominent fault-scarp. The lowest point is Summer Lake.

2.2.2 Lithology and Stratigraphy

Paleozoic and Mesozoic units may occur at undetermined depths in the Summer Lake GRA since this area is within the margins of both the western Triassic and the western Late Paleozoic depositional basins[7]. None of these units, however, are exposed in or near the GRA. Tertiary basalt flows are the oldest rocks exposed in the Summer Lake GRA (Figure 2-2).

FIGURE 2-2

Geologic Map
Summer Lake GRA
(OR-010-27)
Lake County, Oregon



Scale 1:250,000
(Klamath Falls and Crescent 1°x2° NTMS Quadrangles)

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FIGURE 2-2
(Continued)

Geologic Map Legend For
Summer Lake GRA
(OR-010-27)
Lake County, Oregon

Crescent City
(North)

Qd - Dune Sands

Ql - Lacustrine Rocks: Unconsolidated to semi-consolidated lacustrine clay, silt, sand and gravel.

Qf - Fanglomerate

Tat - Silicic Ash-Flow Tuff: Rhyolitic and Rhyodacitic composition.

Tpb - Basalt: Gray open textured olivine basalt flows.

Tb - Basalt: Gray to dark-gray basalt flows, flow breccias, and basalt peperite.

Klamath Falls
(South)

Qal - Alluvium

Qd - Dune Sand

Qpl - Playa Deposits

Qls - Landslide and Debris Flow Deposits

Qs - Lacustrine Sedimentary Rocks

QTvm - Basaltic Vent Rocks: Includes agglomerate, breccia, scoria, cinders, ash, restricted flows, and small basaltic intrusive bodies.

QTp - Deposits of Unconsolidated to Semi-Consolidated Scoriacous Ejecta of Basaltic Cinder Cones

QTb - Basalt

Tat - Silicic Ash-Flow and Associated Pumiceous Air-Fall Tuff: Mostly of rhyolitic and rhyodacitic composition. Grades laterally into tuffaceous sediments of unit Ts.

Tob - Olivine Basalt

FIGURE 2-2
(Concluded)

Geologic Map Legend For
Summer Lake GRA
(OR-010-27)
Lake County, Oregon

Klamath Falls
(South)
(Concluded)

Tvm - Basaltic and Andesitic Agglomerate, Breccia, Cinders, Scoria, Flows, and Intrusive Masses Forming Constructional Volcanic Features.

Tb - Basalt

Tvs - Rhyolitic, Rhyodacitic, and Dacitic Plugs and Exogenous Domal Complexes

Tf - Basalt and Andesite Flows and Breccia: Interfingers and grades laterally into unit Tts.

Tts - Tuffaceous Sedimentary Rocks: Tuffs, pumicites, and silicic flows.

Tvcs - Rhyolitic and Dacitic Domal Masses: Intrusive bodies and related near-vent flows and pyroclastic rocks.

Tsf - Rhyolitic Tuffs: Tuffaceous sedimentary rocks and flows.

 - Fault (dashed where inferred).

 - Geologic contact (dashed where inferred).

The oldest rocks in the GRA occur in the southwest portion of the area along a prominent east-trending fault-scarp that borders the Summer Lake graben. These include rhyolitic tuffs and tuffaceous sedimentary rocks. They are overlain by Mid-Miocene peralkaline extrusives and pyroclastic sequences. These rocks are Middle to Late Miocene. The younger basalts in this area had an original areal extent of several thousand square miles and reached thicknesses of several thousand feet. They underlie most of the GRA. Late Tertiary rocks in this area include felsic and ferro-magnesian tuffs, agglomerates, breccias, and intrusives.

Olivine basalts cover most of the northeastern portion of the Summer Lake GRA, east of the prominent fault-scarp. They are preserved in this part of the GRA because of faulting; they have been eroded from other parts of the area.

Quaternary rocks near Summer Lake include basaltic vent rocks and associated scoriaceous ejecta.

2.2.3 Structural Geology

The major structural elements that characterize the tri-state area of northeastern Nevada, southern Oregon, and southwestern Idaho are typical of the Basin and Range province. These structures include ridges and valleys that resulted from Eaely Cenozoic block faulting. During the Early Paleozoic this area was the site of marine sedimentation in the north-northeast trending Cordilleran geosyncline. Sedimentation persisted in three sub-parallel belts until the end of the Devonian Period. Oregon was the site of eugeoclinal deposits; western Nevada was the site of transitional deposits, and the eastern half of Nevada received near-shore to littoral deposits.

In Late Devonian time, the Antler Orogeny developed along a north-northeast trending axis through northern Nevada, and on into southwestern Idaho[7]. As a direct result of the Antler orogenic uplift, a Pennsylvanian clastic wedge developed along the margins of the uplift and is represented in Oregon by non-marine sandstone. The orogeny culminated in a period of extensive thrust faulting that includes the Roberts' Mountain thrust.

The Sonoma Orogeny occurred in the Permian in north-central Nevada[7] and southern Oregon. This deformational episode included folding and massive volcanic extrusions in

Oregon. A huge eugeocline, the Columbia Trough, developed in eastern Oregon in Middle to Late Mesozoic time and rotated the rocks to their present position. This structural feature extends from the Klamath Mountains to the Wallowa Mountains. The Columbia Trough received thousands of feet of Tertiary eugeoclinal sediments. A tremendous increase in volcanic activity occurred in the tri-state area during the Late Cenozoic. This is recorded by the large volume of Tertiary extrusives that blanket the area.

2.2.4 Paleontology

Potentially fossiliferous rocks are exposed along the major fault-scarps in the area[8]. They include Tertiary tuffaceous siltstones, sandstones, conglomerates, and semi-consolidated lacustrine tuffaceous sandstones, siltstones, and ashy-diatomite. The lacustrine sedimentary unit (map unit Tst) is laterally equivalent to the highly fossilferous Juntura and Deer Butte Formations. These rocks have a moderate to high potential for paleontological resources within the Summer Lake GRA.

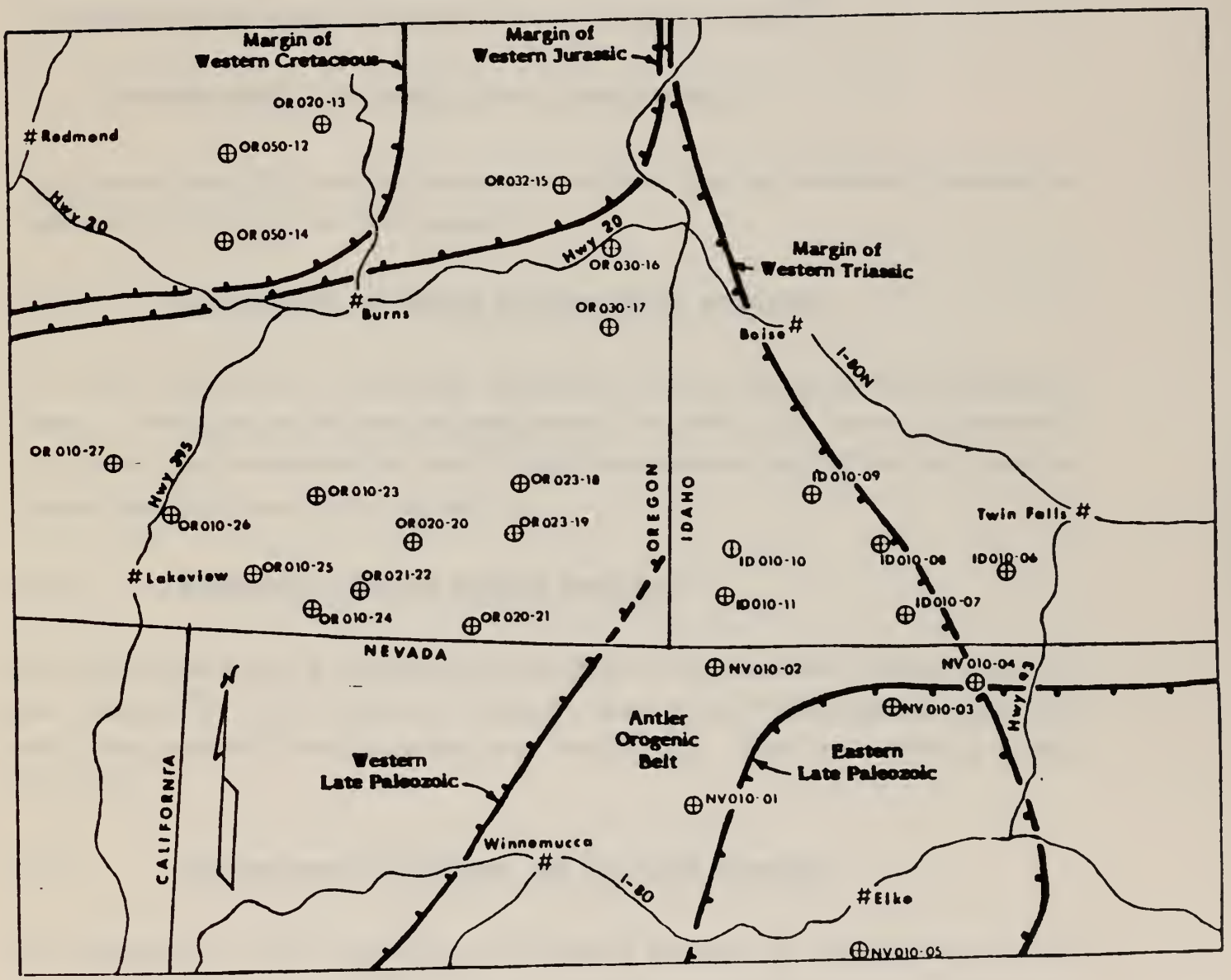
2.2.5 Historical Geology

The present character of the Great Basin resulted from the progressive development of the western portion of the North American continent throughout geologic time. Beginning in the Late Precambrian and continuing into the Middle Paleozoic, western Nevada and southern Oregon were in a eugeoclinal environment in which dark shales, radiolarian cherts, and basaltic materials (Steinman's Trinity) were formed. Eastern Nevada, western Utah, and southwesternmost Idaho were characterized by a miogeoclinal environment in which shelf margin carbonates, shales, and sandstones were deposited.

The Middle Paleozoic (Late Devonian-Early Mississippian) Antler Orogeny deformed and thrust the eugeoclinal sediments over the shelf-type sediments to the east, resulting in the north-trending Antler Highlands in Central Nevada. Erosion of the Antler Highlands resulted in the deposition of coarse sediments during the Early Pennsylvanian. Thousands of feet of sandstone were deposited in southern Oregon around the margins of the Antler Highlands. Late Pennsylvanian and Permian shallow water sediments overlapped and overstepped the roots of the eroded Antler Highlands. Sediments deposited over the Antler Highlands in the Permian were predominantly of the deep-water variety. The next significant tectonic episode (the Sonoma Orogeny) thrust the ocean floor siliceous and volcanic materials eastward over the shallow water, clastic sedimentary rocks that covered the ancient Antler Highlands.

FIGURE 2-3

Paleogeographic Map[6]
Oregon-Idaho-Nevada
Tri-State Area



Development of western North American in the Mesozoic was dominated by oceanic plate subduction along the continental margin that resulted in a complex history of concomittant sedimentation, deformation, and igneous activity. During this time, the well-defined overthrust belt that extends from Canada to Mexico was formed. This deformation occurred during the Sevier (Late Jurassic to Latest Cretaceous) and Laramide orogenies (Latest Cretaceous to Early Tertiary Eocene)[7].

2.3 ENVIRONMENTS FAVORABLE FOR GEM RESOURCES

The Summer Lake GRA contains several environments that are moderately favorable to highly favorable for several GEM resources.

2.3.1 Environments for Metals and Non-Metals Resources

The Summer Lake GRA is moderately favorable for the occurrence of evaporative salts. Direct evidence for the existence of these mineral resources in the waters and sediments of Summer Lake is confirmed by Weis[9]. Rocks that underlie this GRA are not known to contain metallic mineral accumulations.

2.3.2 Environments for Oil and Gas Resources

The Summer Lake GRA is moderately favorable for the accumulation of potential oil and gas resources[7]. It lies within the western margin of the Triassic marine basin and within the projected limits of the Miocene Lake Bruneau. Minor shows occur in or near this GRA.

2.3.3 Environments for Oil Shale and Tar Sands Resources

The Summer Lake GRA contains no environments favorable for the occurrence of oil shale or oil impregnated sand[10]. The area is underlain predominantly by Tertiary felsic to mafic volcanic rocks. Potential sedimentary hosts are largely tuffaceous and contain only minor amounts of non-volcanic clastics. Favorable lithologies are not present in this study area.

2.3.4 Environments for Geothermal Resources

The Summer Lake GRA contains environments favorable for geothermal resources. The graben and its margins represent environments that are moderately favorable for geothermal resources[11]. Recent faulting, young volcanics, and the regional hydrology of the area are all supportive criteria for the favorability of geothermal resources. The Summer Lake KGRA is just south of the WSA. There has been geothermal leasing in and near this KGRA. Several warm-springs also exist in the Summer Lake GRA.

2.3.5 Environments for Uranium and Thorium Resources

There are no environments favorable for the occurrence of uranium or thorium resources in the Summer Lake GRA[12]. The majority of the GRA is underlain by Tertiary volcanogenic rocks that are not favorable for the occurrence of these resources.

2.3.6 Environments for Coal Resources

The Summer Lake GRA has a low favorability for the occurrence of coal and lignite deposits[13]. The chances for coal or carbonaceous materials to have formed in the study area are remote. The geology of the Summer Lake GRA region does not support environments favorable for the formation of coal deposits. The area is underlain or is mantled with accumulations of highly tuffaceous sediments and related volcanic products. There is no direct evidence to support the inference that a coal-forming environment existed within this GRA.

2.3.7 Environments for Industrial Minerals Resources

The Summer Lake GRA has a low favorability for the accumulation of both diatomite and bentonite GEM rsources[14]. Lacustrine and felsic volcanic rocks are the necessary host environments for the development of diatomite and bentonite.

The study area is not favorable for the occurrence of limestone and clinoptilolite resources. Although a limestone-forming geological environment existed in the past, the depth to the potential resource is excessive. No clinoptilolite occurrences are known to exist in the area although a favorable volcanic environment may be present.

2.3.8 Environments for Paleontological Resources

The Summer Lake GRA is classified as highly favorable for paleontological resources[8]. A Pleistocene non-marine fossil site occurs within WSA 1-58. Tuffaceous sediments and air-fall tuffs also may contain Tertiary fossil assemblages. However, no localities are known in these strata.

2.3.9 Environments for Geologic Hazards

Potential geologic hazards in the Summer Lake GRA consist of mapped and interpreted faults, landslides, and/or volcanic centers[14]. These features were noted from aerial photographs, geologic maps, and topographic maps. There is no historical record of violent seismic or volcanic activity the area. The potential for mass movement exists along all over-steepened slopes within the GRA.

2.3.10 Educational and Scientific Localities

There are no known ESLs in the Summer Lake GRA.

3. ENERGY AND MINERAL RESOURCES IN THE SUMMER LAKE GRA

The Summer Lake GRA has a moderately high favorability for the occurrence of several GEM resources.

3.1 KNOWN DEPOSITS

The Summer Lake GRA contains no known deposits.

3.2 OCCURRENCES

The Summer Lake GRA contains eight MILS localities (Figure 3-1). One MILS locality is related to a non-producing mercury occurrence that is located near Paisley, Oregon. The remaining MILS localities include geothermal test wells and gravel pits. The Summer Lake GRA contains no CRIB or NURE-related occurrences. The Brattain Mining District and associated claims occur outside of the GRA, south of Paisley, Oregon (personnal communication, D. Simontacchi, Lakeview District BLM Office).

3.3 CLAIMS

The Summer Lake GRA contains no known claims as of 15 August, 1982.

3.4 LEASES

Seventy-five percent of WSA 1-58 is leased or under lease application for oil and gas. Lease information is current as of 15 August, 1982.

3.5 DEPOSIT TYPES

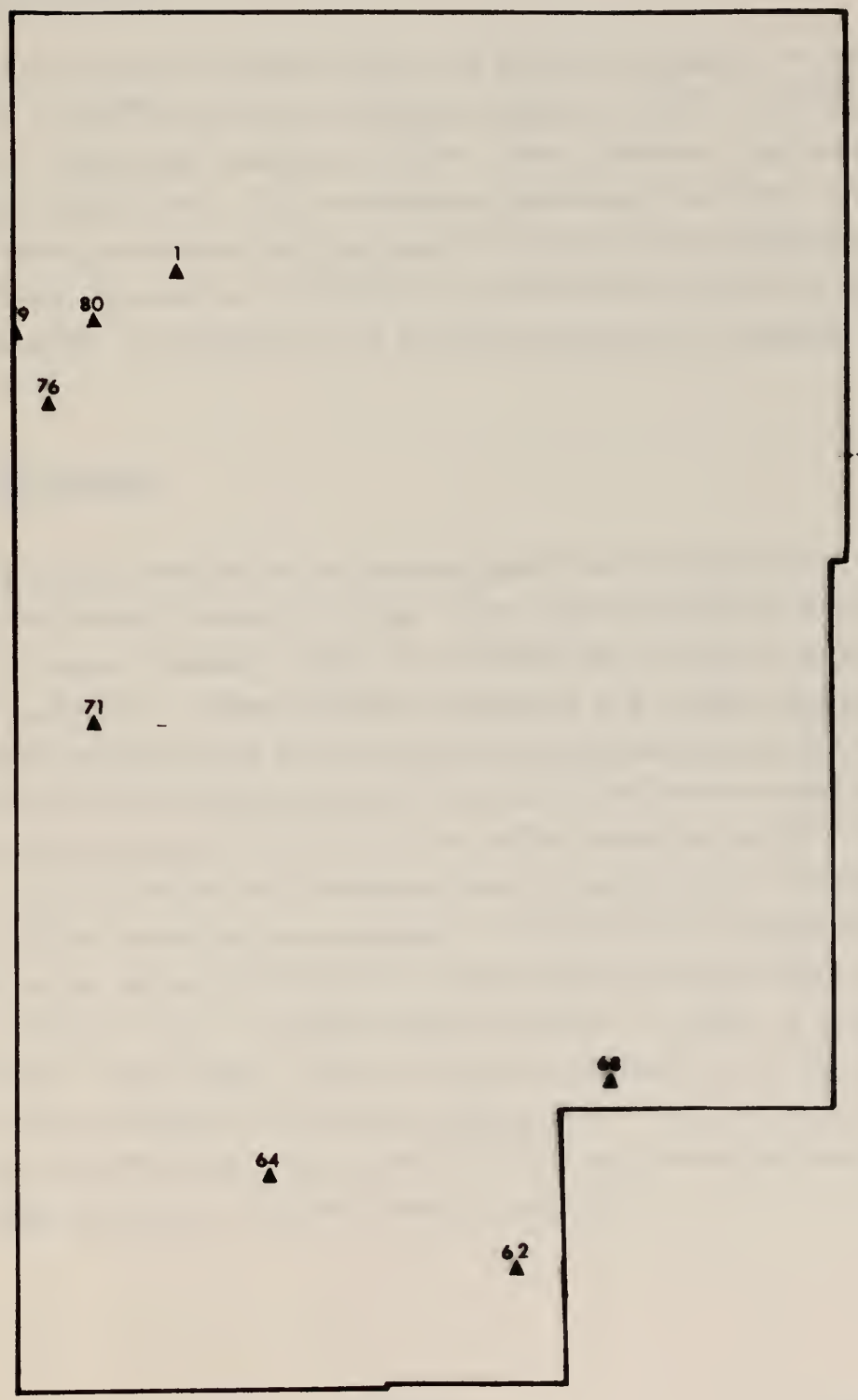
With the exception of geothermal resources there are no known deposits in the Summer Lake GRA. Reservoir specifications are not well known for the geothermal occurrences. Reservoir temperatures are less than the minimum desired for commercial production of electricity[11].

FIGURE 3-1

MILS Localities Map
Summer Lake GRA
(OR - 010 - 27)
Lake County, Oregon

N

1
▲ = Site Keyed To Explanation



Scale 1:250,000
(Klamath Falls and Crescent $1^{o}x2^{o}$ NTMS Quadrangles)

3.6 MINERAL ECONOMICS

The Summer Lake GRA is considered moderately favorable for the occurrence of geothermal resources, oil and gas, and evaporative salts.

3.6.1 Geothermal

Geothermal resources may be classified into two general categories; low-temperature resources (96°F to 196°F), and high-temperature resources (196°F to 302°F). Uses of low-temperature geothermal resources include local industrial, agricultural, and domestic heating applications. High-temperature geothermal resources currently are used only in limited commercial electrical generation and research applications. Supply, demand, and price data are not established for this resource because of the limited amount of production. The importance of geothermal resources is generally of a local nature[11].

3.6.2 Oil and Gas

Oil and gas are vitally important to the industrial growth and development of the United States, and to the overall standard of living. Gross supply and demand trends indicate that during the present decade foreign oil will make up at least 45 percent of our national oil requirements. Present domestic production is 8.6 million barrels per day. The United States currently has a 37 million barrel per day equivalent energy demand. It is predicted that by 1990 the United States will produce 8.8 million barrels of oil per day. The equivalent energy demand will increase to 40 million barrels per day[18]. During this same period, crude oil demand will decrease by nearly 5 percent, from 16 million barrels per day to 14 million barrels per day equivalent. This decrease is thought to be related to an increase in the use and development of other domestic energy sources, consumer conservation practices, and a predicted slight increase in crude oil production by 1990[18]. Because most shallow sources of crude have been or are being depleted, deeper, more difficult targets of oil and gas are being sought. This may result in a rise in the price of crude by 1990 to $61.00 per barrel[18]. This may reverse the trend of surplus supplies that began last year. It also may cause shortages[19].

3.7 STRATEGIC AND CRITICAL MINERALS AND METALS

The Summer Lake GRA may contain environments favorable for potassium salts and borates. (See the BLM compilation given in Table 3-4 of TERRADATA's report "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.") The lack of detailed sub-surface investigations makes evaluation of these evaporate resources difficult.

4. CLASSIFICATION OF LAND FOR GEM RESOURCES POTENTIAL

The precise location of specific favorable environments within a given GRA depends upon three principal factors:

- The precision and specificity of avaliable data;
- The nature (size and spatial distribution) of anticipated deposits as predicted from known models; and
- The geometry of the favorable geologic environments.

Commodity-specific information in the Summer Lake GRA is limited. Sub-surface information is virtually non-existent. Therefore, the entire area, rather than specific subareas, has been classified for most GEM resources (Figure 4-1 and Table 4-1).

The Summer Lake GRA is highly favorable (Class 4B) for paleontological resources.

The presence of fossil localities in Quaternary (Pliestocene) lake sediments and Tertiary tuffaceous sediments enhances the potential for this resource. A confidence level of B is given to this evaluation because the precise location of the occurrences is not known.

The entire GRA is classified moderately favorable (3B) for oil and gas resources. The area is within the limits of the western Triassic marine basin and within the projected limits of Miocene Lake Bruneau. The GRA is partially leased. There is only indirect evidence for possible hydrocarbon accumulations. Therefore, a confidence level of B is given for this evaluation. TERRADATA's classification of the area for oil and gas potential agrees with the USGS evaluation of the area for these resources[16]

The presence of warm springs and the favorable structural setting of Summer Lake are reasons for classifying the GRA as moderately favorable (Class 3) for geothermal resources. The Summer Lake graben (Area 1-3C) is moderately favorable for geothermal resources because of recent tectonic movement and volcanic acitivity. The confidence level (C) of the classificiation indicates that minimal direct evidence was available for the evaluation.

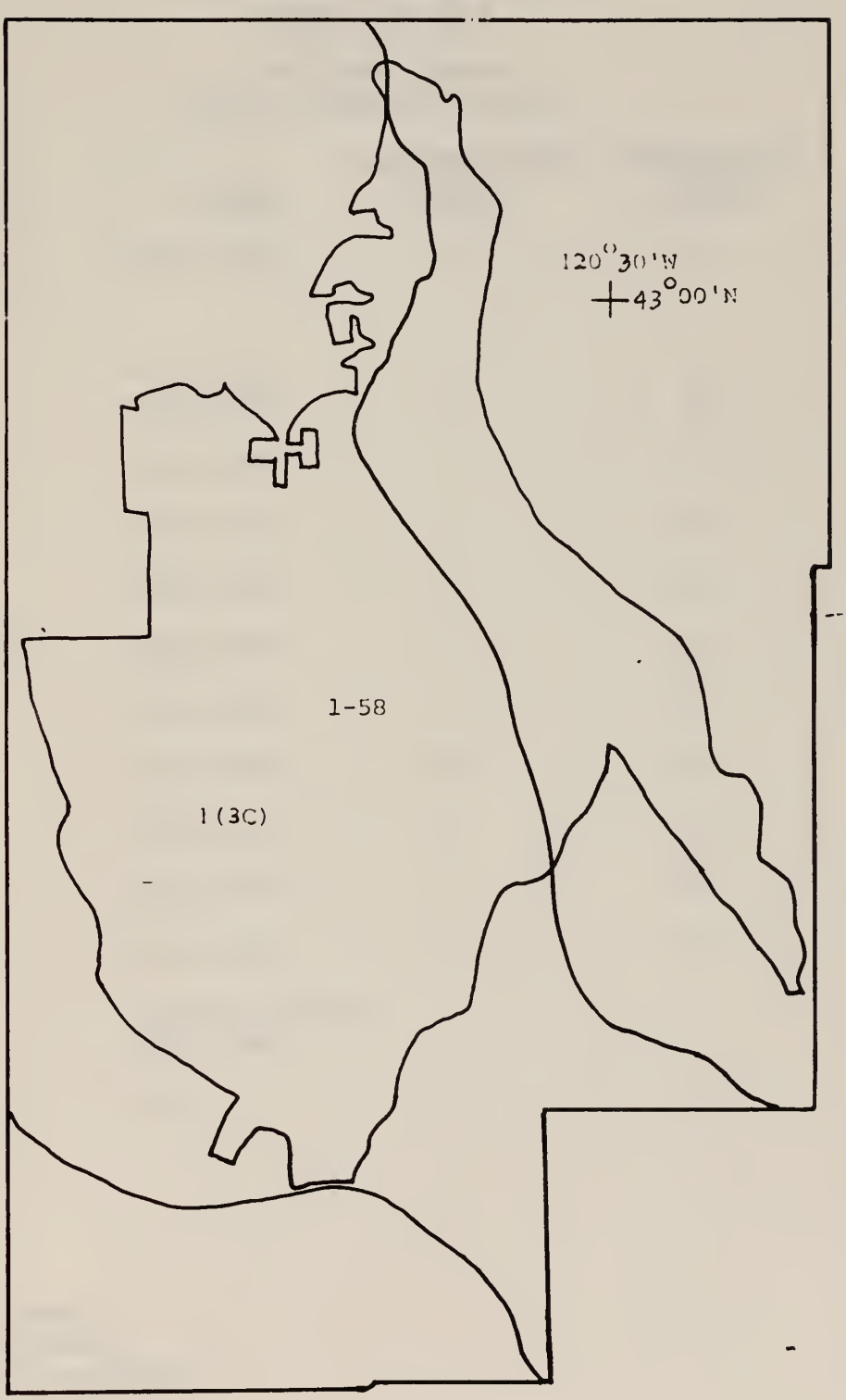
The Summer Lake GRA also is moderately favorable for evaporative salts. The presence of playa areas and the historical persistence of an arid to semi-arid climate are favorable criteria for the occurrence of deposits of evaporative mineral resources in the playa sediments. Potassium and borate resources also are in this area.

Coal, diatomite, and bentonite have low favorabilities in the Summer Lake GRA. Lacustrine and volcanic strata are potential host environments for the formation of these resources. No deposits of these resources are known in or near the GRA. Historic references to some low-grade lignite seams in Oregon, and minor amounts of coal in Idaho, suggest that there is a possibility for the presence of coal in the area. Confidence levels of B or C for these classifications signify that they are based on minimal indirect evidence.

The Summer Lake GRA does not exhibit favorable characteristics (Class 1) for any other commodities. TERRADATA's classifications of the Summer Lake GRA for all potential leasable resources agree with the USGS classification of the area for the same resources[16, 17].

FIGURE 4-1

Land Classification Map
Summer Lake GRA
(OR-010-27)
Lake County, Oregon



This map is an overlay for Figures 2-1 and 2-2.

Scale 1:250,000
(Klamath Falls and Crescent 1°x2° NTMS Quadrangles)

TABLE 4-1

Classification Of Lands Within The
Summer Lake GRA
(OR - 010 - 27)
Lake County, Oregon
For GEM Resource Potential

COMMODITY	AREA	CLASSIFICATION LEVEL	CONFIDENCE LEVEL	REMARKS
Metals/Non-Metals	Entire GRA	3	B	Sodium Salt, Potassium Salt, and Borates
Geothermal	Area 1-3C	3	C	
	Rest of GRA	1	B	
Uranium/Thorium	Entire GRA	1	A	
Coal	Entire GRA	2	B	
Oil and Gas	Entire GRA	3	B	
Tar Sands/Oil Shale	Entire GRA	1	C	
Limestone	Entire GRA	1	B	
Bentonite	Entire GRA	2	C	
Diatomite	Entire GRA	2	C	
Clinoptilolite	Entire GRA	1	C	
Paleontology	Entire GRA	4	B	
Hazards	See Hazards Map (GRA File)			
ESLs	None	1	C	

LEGEND:
Class 1 - Least Favorable
Class 2 - Low Favorability
Class 3 - Moderate Favorability
Class 4 - High Favorability

Confidence Level A - Insufficient data or no direct evidence
Confidence Level B - Indirect evidence available
Confidence Level C - Direct evidence but quantitatively minimal
Confidence Level D - Abundant direct and indirect evidence

5. RECOMMENDATIONS FOR FUTURE WORK

Future work in the Summer Lake GRA should be designed to increase the confidence levels of the classifications. Detailed surface investigations should be undertaken for recognition criteria for industrial minerals (e.g., weathering phenomena that might produce bentonite or clinoptilolite; ash flow tuffs with possible basal vitrophyres for perlite, etc.) and for additional evaporite and metallic deposits (soil chemistry, stream sediment analyses, etc). With the exception of either geophysical investigations or drilling, future work should be confined to detailed mapping, geochemical sampling, and general field exploration.

- APPENDIX A -

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- APPENDIX B -

Explanation For Firgure 3-1

FIGURE 3-1
(Continued)

Explanation For
MILS Localities Map
Summer Lake GRA
(OR - 010 - 27)
Lake County, Oregon

```
   1
1  NAME- JOHNSON CREEK SPRINGS                    REFERENCE NUMBER- 0410370052
   STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1311M:500M
   LATITUDE-   N 43 00 45         PRECISION-   1KM
   LONGITUDE- W 120 41 15  REFERENCE POINT- APPROX
   UTM:  ZONE 10N  NORTHING 4764583  EASTING 688458
   PUBLIC LAND SURVEY  TOWNSHIP- 029 S   RANGE- 017 E
      DESCRIPTION      SECTION- 31  SECTION SUBDIVISION-
   RIVER BASIN- 67H   FORK ROCK-SILVER LK          DOMAIN- UNKNOWN
   STATUS- PRODUCER         OPERATION TYPE- WELL
   MESA ID NO.             YEAR FIELD CHECKED-       MAP REPOSITORY-  FOC
   MAP NAME- CRESCENT              TYPE- 1:250K
   1:250,000 MAP NAME- CRESCENT              MINERAL PROPERTY FILE-
   PRIMARY NAME- JOHNSON CREEK SPRINGS
   COMMOD MOD-  GEOTHERMAL
   USGS PROFESSIONAL PAPER 492
   12 MILES NE OF SUMMER LAKE POST OFFICE; SEVERAL SPRINGS, WAT
   FOR IRRIGATION. FLOW OF 9000 GALLONS PER MINUTE.


   31
62 NAME- BUCKEROO PIT                             REFERENCE NUMBER- 0410370084
   STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1341M:500M
   LATITUDE-   N 42 41 49         PRECISION-  500M
   LONGITUDE- W 120 32 37  REFERENCE POINT- TRENCH
   UTM:  ZONE 10N  NORTHING 4729872  EASTING 701208
   PUBLIC LAND SURVEY  TOWNSHIP- 033 S   RANGE- 018 E
      DESCRIPTION      SECTION- 24  SECTION SUBDIVISION-
   RIVER BASIN-                                 DOMAIN- UNKNOWN
   STATUS- UNKNOWN          OPERATION TYPE- SURFACE
   MESA ID NO. 35 01080  YEAR FIELD CHECKED-       MAP REPOSITORY-  FOC
   MAP NAME- PAISLEY               TYPE- 7.5 MIN
   1:250,000 MAP NAME- KLAMATH FALLS         MINERAL PROPERTY FILE-
   PRIMARY NAME- BUCKEROO PIT
   COMMOD MOD-  STONE              MISCELLANEOUS DM
   MESA

   32
62 NAME- GOVERNMENT HARVEY PIT                    REFERENCE NUMBER- 0410370086
   STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1341M:500M
   LATITUDE-   N 42 41 49         PRECISION-  500M
   LONGITUDE- W 120 32 37  REFERENCE POINT- TRENCH
   UTM:  ZONE 10N  NORTHING 4729872  EASTING 701208
   PUBLIC LAND SURVEY  TOWNSHIP- 033 S   RANGE- 018 E
      DESCRIPTION      SECTION- 24  SECTION SUBDIVISION-
   RIVER BASIN-                                 DOMAIN- UNKNOWN
   STATUS- UNKNOWN          OPERATION TYPE- SURFACE
   MESA ID NO. 35 01077  YEAR FIELD CHECKED-       MAP REPOSITORY-  FOC
   MAP NAME- PAISLEY               TYPE- 7.5 MIN
   1:250,000 MAP NAME- KLAMATH FALLS         MINERAL PROPERTY FILE-
   PRIMARY NAME- GOVERNMENT HARVEY PIT
   COMMOD MOD-  STONE              MISCELLANEOUS DM
   MESA
```

FIGURE 3-1
(Continued)

Explanation For
MILS Localities Map
Summer Lake GRA
(OR - 010 - 27)
Lake County, Oregon

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   94
 64 NAME- SUMMER LAKE HOT SPRING                    REFERENCE NUMBER- 0410370060
    STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1290M:500M
    LATITUDE-   N 42 43 32         PRECISION-  100M
    LONGITUDE- W 120 38 51  REFERENCE POINT- APPROX
    UTM:  ZONE 10N  NORTHING 4732807  EASTING 692609
    PUBLIC LAND SURVEY  TOWNSHIP- 033 S   RANGE- 017 E
        DESCRIPTION     SECTION- 11  SECTION SUBDIVISION- SWNENE
    RIVER BASIN- 67H   FORK ROCK-SILVER LK        DOMAIN- PRIVATE
    STATUS- PRODUCER        OPERATION TYPE- WELL
    MESA ID NO.           YEAR FIELD CHECKED-      MAP REPOSITORY-  FOC
    MAP NAME- SLIDE MTN          TYPE- 7.5 MIN
    1:250,000 MAP NAME- KLAMATH FALLS       MINERAL PROPERTY FILE-
    PRIMARY NAME- SUMMER LAKE HOT SPRING
    OTHER NAMES-  WOODWARD HOT SPRINGS
                  J. W. FARLEIGH S HOT SPRINGS
    COMMOD/MOD-  GEOTHERMAL
    USGS PROFESSIONAL PAPER 492
    3 MAIN SPRINGS, WATER SMELLS OF H2S, USED FOR BATHING AND
    IRRIGATION, DEPOSIT OF SILICEOUS SINTER

   98
 68 NAME- KINGWELL MERCURY                          REFERENCE NUMBER- 0410370020
    STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1432M:500M
    LATITUDE-   N 42 45 20         PRECISION-   1KM
    LONGITUDE- W 120 30 14  REFERENCE POINT- ORE BODY
    UTM:  ZONE 10N  NORTHING 4736476  EASTING 704270
    PUBLIC LAND SURVEY  TOWNSHIP- 032 S   RANGE- 019 E
        DESCRIPTION     SECTION- 32  SECTION SUBDIVISION-
    RIVER BASIN- 67H   FORK ROCK-SILVER LK        DOMAIN- BLM ADMIN
    STATUS- RAW PROSPECT   OPERATION TYPE- PROSPECT
    MESA ID NO.           YEAR FIELD CHECKED-      MAP REPOSITORY-  FOC
    MAP NAME- KLAMATH FALLS      TYPE- 1:250K
    1:250,000 MAP NAME- KLAMATH FALLS       MINERAL PROPERTY FILE-
    PRIMARY NAME- KINGWELL MERCURY
    COMMOD/MOD-  MERCURY

  101
 71 NAME- THOUSAND SPRINGS                          REFERENCE NUMBER- 0410370053
    STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1301M:500M
    LATITUDE-   N 42 52 05         PRECISION-   1KM
    LONGITUDE- W 120 43 20  REFERENCE POINT- APPROX
    UTM:  ZONE 10N  NORTHING 4748464  EASTING 686063
    PUBLIC LAND SURVEY  TOWNSHIP- 032 S   RANGE- 018 E
        DESCRIPTION     SECTION- 19  SECTION SUBDIVISION-
    RIVER BASIN- 67H   FORK ROCK-SILVER LK        DOMAIN- PRIVATE
    STATUS- PRODUCER        OPERATION TYPE- WELL
    MESA ID NO.           YEAR FIELD CHECKED-      MAP REPOSITORY-  FOC
    MAP NAME- KLAMATH FALLS      TYPE- 1:250K
    1:250,000 MAP NAME- KLAMATH FALLS       MINERAL PROPERTY FILE-
    PRIMARY NAME- THOUSAND SPRINGS
    COMMOD/MOD-  GEOTHERMAL
    USGS PROFESSIONAL PAPER 492
    ON EAST SIDE OF SUMMER LAKE VALLEY; MANY SMALL SPRINGS, WATE
    FOR IRRIGATION
```

FIGURE 3-1
(Continued)

Explanation For
MILS Localities Map
Summer Lake GRA
(OR - 010 - 27)
Lake County, Oregon

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  106
76 NAME- J. G. FOSTER S SPRING                    REFERENCE NUMBER- 0410370057
   STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1280M:500M
   LATITUDE-   N 42 58 00        PRECISION- >10KM
   LONGITUDE- W 120 44 00  REFERENCE POINT- APPROX
   UTM:  ZONE 10N  NORTHING 4759340  EASTING 684861
   PUBLIC LAND SURVEY  TOWNSHIP- 030 S   RANGE- 017 E
       DESCRIPTION     SECTION- 18  SECTION SUBDIVISION-
   RIVER BASIN- 67H   FORK ROCK-SILVER LK         DOMAIN- UNKNOWN
   STATUS- PRODUCER       OPERATION TYPE- WELL
   MESA ID NO.           YEAR FIELD CHECKED-       MAP REPOSITORY-  FOC
   MAP NAME- KLAMATH FALLS      TYPE- 1:250K
   1:250,000 MAP NAME- KLAMATH FALLS       MINERAL PROPERTY FILE-
   PRIMARY NAME- J. G. FOSTER S SPRING
   COMMOD/MOD-  GEOTHERMAL
   USGS PROFESSIONAL PAPER 492
   5 SPRINGS, WATER USED FOR IRRIGATION.

  107
76 NAME- LOST CABIN SPRING                        REFERENCE NUMBER- 0410370058
   STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1280M:500M
   LATITUDE-   N 42 58 00        PRECISION- >10KM
   LONGITUDE- W 120 44 00  REFERENCE POINT- APPROX
   UTM:  ZONE 10N  NORTHING 4759340  EASTING 684861
   PUBLIC LAND SURVEY  TOWNSHIP- 030 S   RANGE- 017 E
       DESCRIPTION     SECTION- 18  SECTION SUBDIVISION-
   RIVER BASIN- 67H   FORK ROCK-SILVER LK         DOMAIN- UNKNOWN
   STATUS- PRODUCER       OPERATION TYPE- WELL
   MESA ID NO.           YEAR FIELD CHECKED-       MAP REPOSITORY-  FOC
   MAP NAME- KLAMATH FALLS      TYPE- 1:250K
   1:250,000 MAP NAME- KLAMATH FALLS       MINERAL PROPERTY FILE-
   PRIMARY NAME- LOST CABIN SPRING
   COMMOD/MOD-  GEOTHERMAL
   USGS PROFESSIONAL PAPER 492
   WATER SUPPLY FOR CATTLE.

  108
76 NAME- P. C. FOSTER S SPRING                    REFERENCE NUMBER- 0410370054
   STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1280M:500M
   LATITUDE-   N 42 58 05        PRECISION-   5KM
   LONGITUDE- W 120 44 30  REFERENCE POINT- APPROX
   UTM:  ZONE 10N  NORTHING 4759526  EASTING 684177
   PUBLIC LAND SURVEY  TOWNSHIP- 030 S   RANGE- 017 E
       DESCRIPTION     SECTION- 18  SECTION SUBDIVISION-
   RIVER BASIN- 67H   FORK ROCK-SILVER LK         DOMAIN- PRIVATE
   STATUS- PRODUCER       OPERATION TYPE- WELL
   MESA ID NO.           YEAR FIELD CHECKED-       MAP REPOSITORY-  FOC
   MAP NAME- KLAMATH FALLS      TYPE- 1:250K
   1:250,000 MAP NAME- KLAMATH FALLS       MINERAL PROPERTY FILE-
   PRIMARY NAME- P. C. FOSTER S SPRING
   COMMOD/MOD-  GEOTHERMAL
   USGS PROFESSIONAL PAPER 492
   2 MILES SW OF ANA RIVER; WATER USED FOR IRRIGATION.
```

FIGURE 3-1
(Continued)

Explanation For
MILS Localities Map
Summer Lake GRA
Lake County, Oregon

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  109
76 NAME- RUSSELL EMERY S SPRING                REFERENCE NUMBER- 0410370056
   STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1280M:500M
   LATITUDE-   N 42 58 00         PRECISION- >10KM
   LONGITUDE- W 120 44 00  REFERENCE POINT- APPROX
   UTM:  ZONE 10N  NORTHING 4759390  EASTING 684861
   PUBLIC LAND SURVEY  TOWNSHIP- 030 S   RANGE- 017 E
       DESCRIPTION     SECTION- 18  SECTION SUBDIVISION-
   RIVER BASIN- 67H   FORK ROCK-SILVER LK         DOMAIN- UNKNOWN
   STATUS- PRODUCER        OPERATION TYPE- WELL
   MESA ID NO.            YEAR FIELD CHECKED-       MAP REPOSITORY-  FOC
   MAP NAME- KLAMATH FALLS       TYPE- 1:250K
   1:250,000 MAP NAME- KLAMATH FALLS        MINERAL PROPERTY FILE-
   PRIMARY NAME- RUSSELL EMERY S SPRING
   COMMOD MOD-  GEOTHERMAL
   USGS PROFESSIONAL PAPER

  110
76 NAME- W. O. GRISEL S SPRING                 REFERENCE NUMBER- 0410370055
   STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1280M:500M
   LATITUDE-   N 42 58 00         PRECISION- >10KM
   LONGITUDE- W 120 44 00  REFERENCE POINT- APPROX
   UTM:  ZONE 10N  NORTHING 4759390  EASTING 684861
   PUBLIC LAND SURVEY  TOWNSHIP- 030 S   RANGE- 017 E
       DESCRIPTION     SECTION- 18  SECTION SUBDIVISION-
   RIVER BASIN- 67H   FORK ROCK-SILVER LK         DOMAIN- UNKNOWN
   STATUS- PRODUCER        OPERATION TYPE- WELL
   MESA ID NO.            YEAR FIELD CHECKED-       MAP REPOSITORY-  FOC
   MAP NAME- KLAMATH FALLS       TYPE- 1:250K
   1:250,000 MAP NAME- KLAMATH FALLS        MINERAL PROPERTY FILE-
   PRIMARY NAME- W. O. GRISEL S SPRING
   COMMOD MOD-  GEOTHERMAL
   USGS PROFESSIONAL PAPER 492
   WATER USED FOR DOMESTIC PURPOSES AND IRRIGATION.
```

FIGURE 3-1
(Concluded)

Explanation For
MILS Localities Map
Summer Lake GRA
Lake County, Oregon

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  113
79 NAME- ANA RIVER SPRINGS                          REFERENCE NUMBER- 0410370050
   STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1280M:500M
   LATITUDE-   N 42 59 25          PRECISION-   1KM
   LONGITUDE- W 120 45 20  REFERENCE POINT- APPROX
   UTM:  ZONE 10N  NORTHING 4761963  EASTING 682979
   PUBLIC LAND SURVEY  TOWNSHIP- 030 S   RANGE- 017 E
       DESCRIPTION     SECTION- 05  SECTION SUBDIVISION-
   RIVER BASIN- 67H   FORK ROCK-SILVER LK          DOMAIN- UNKNOWN
   STATUS- PRODUCER        OPERATION TYPE- WELL
   MESA ID NO.            YEAR FIELD CHECKED-       MAP REPOSITORY-  FOC
   MAP NAME- KLAMATH FALLS       TYPE- 1:250K
   1:250,000 MAP NAME- KLAMATH FALLS        MINERAL PROPERTY FILE-
   PRIMARY NAME- ANA RIVER SPRINGS
   COMMOD/MOD-  GEOTHERMAL
   USGS PROFESSIONAL PAPER 492
   7 MILES NORTH OF SUMMER LAKE POST OFFICE; WATER SUPPLY FOR S
   LAKE IRRIGATION DISTRICT.  FLOW OF 48000-75000 GALLONS PER M

  114
80 NAME- BUCKHORN CREEK SPRINGS                     REFERENCE NUMBER- 0410370051
   STATE- OREGON                    COUNTY- LAKE                    ELEV:PREC- 1280M:500M
   LATITUDE-   N 42 59 40          PRECISION-   1KM
   LONGITUDE- W 120 43 20  REFERENCE POINT- APPROX
   UTM:  ZONE 10N  NORTHING 4762500  EASTING 685683
   PUBLIC LAND SURVEY  TOWNSHIP- 030 S   RANGE- 017 E
       DESCRIPTION     SECTION- 05  SECTION SUBDIVISION-
   RIVER BASIN- 67H   FORK ROCK-SILVER LK          DOMAIN- UNKNOWN
   STATUS- PRODUCER        OPERATION TYPE- WELL
   MESA ID NO.            YEAR FIELD CHECKED-       MAP REPOSITORY-  FOC
   MAP NAME- KLAMATH FALLS       TYPE- 1:250K
   1:250,000 MAP NAME- KLAMATH FALLS        MINERAL PROPERTY FILE-
   PRIMARY NAME  BUCKHORN CREEK SPRINGS
   COMMOD/MOD-  GEOTHERMAL
   USGS PROFESSIONAL PAPER 492
   9 MILES NORTH OF SUMMER LAKE POST OFFICE; SEVERAL SPRINGS, W
   USED FOR IRRIGATION. FLOW OF 1000 GALLONS PER MINUTE.

   NAME- BARRY RANCH HOT SPRINGS                    REFERENCE NUMBER- 0410370070
   PRIMARY NAME-     13 GUS ALLEN S HOT SPRINGS
```